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MODIFIED EQUIPMENT FOR PASTEURIZING AND DEODORIZING MARKET MILK AND FOR PASTEURIZING, DEODORIZING, AND SLIGHTLY CONCENTRATING CHEESE MILK

Two important modifications in equipment used for pasteurizing and deodorizing milk have been designed and tested experimentally on a pilot-plant scale, one for processing market milk, the other for processing cheese millk. Each type has a capacity of about 5,000 lb per hour. They were designed primarily to provide equipment that could be operated over a wide range of temperature-time conditions in research, such as from 161 degrees with 15 sec holding time to 195 F with no holding time, except that needed to accentuate the controls, for the pasteurizer, and from 195 to 90 F for the vacuum, vapor-liquid separating chamber. Thus, they differed from most of the available equipment designed to operate under relatively fixed time-temperature conditions. In designing the modified equipment, consideration was given to a more efficient utilization of heat than is possible with present commercial equipment. A conventional HTST plate-pasteurizer operated at 165 F with a 15-sec holding time was employed for comparative purposes. The milk was not homogenized, because in most instances it was treated for use in making cheese. This report describes the two types of experimental equipment and briefly summarizes results obtained with them.

For market milk, a heat regenerator, a plate-type preheater, a steam injector, and a vacuum chamber were arranged and operated as illustrated in Figure 1. This equipment combines preheating, pasteurization by steam injection, and deodorization in a continuous procedure without altering the volume of resulting milk. It is designated as the steam injection–deodorization method. The equipment is operated as follows: The incoming cold, raw milk enters a float tank (1), where a constant level is maintained. From the tank, the milk is drawn by suction of a timing pump (6) through a heat regenerator (2), then on through a plate-type preheater (3) which has a heating regulator (4) and a recording controller (5) actuated by a thermal bulb located in the milk outlet of the preheater.

The raw milk, preheated to a definite predetermined temperature, is discharged under positive pressure from the timing pump (6) through the steam injection heater (7), which has a steam regulator (8) and a recording controller (9) actuated by a thermal bulb (10) located in the inlet of the holder tube (13). The steam-treated milk under positive pressure passes through the holder tube. A flow diversion valve (14) is connected at the outlet of the holder

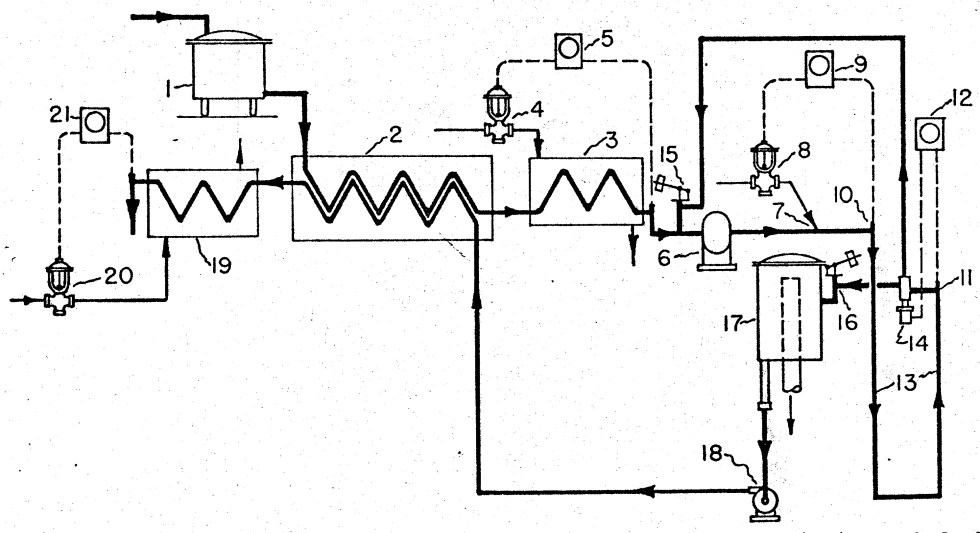

FIG. 1. Diagrammatic drawing of equipment for steam injection–deodorization method of processing market milk.

tube and is operated by a recording controller (12) actuated by a thermal bulb (11) located near the outlet. Thus, any milk below the desired temperature is diverted and injected through a weight-loaded valve (15) back into the intake line of the timing pump (6).

Milk that has been thus pasteurized at the predetermined temperature is ready to be deodorized and cooled. It is still under pressure of the timing pump (6) and passes through a weight-loaded valve (16) which causes a back-pressure on the holder tube but allows the heat-treated milk to enter the vapor-liquid separator (17) which, if the milk flow has been diverted, seals off the vapor-liquid separator.

The milk is flash-cooled in the vapor-liquid separator to a predetermined and controlled temperature corresponding to the vacuum in the vapor-liquid separator. At this stage, the volatile flavors and the water injected in the form of steam during the steam injection stage are removed. The pasteurized and deodorized milk is withdrawn from the vacuum chamber by a pump (18), which propels it through the heat regenerator (2), then through the cooler (19) which has a temperature regulator (20) operated by a recording controller (21). The cooler need not be used if the incoming raw milk is cold enough to cool the outgoing pasteurized milk in the regenerator (2).

For pasteurizing, deodorizing, and slightly condensing milk to be used in making cheese, a plate-type heater and a vacuum chamber were arranged and operated as illustrated in Figure 2. It is designated as the pasteurization-deodorization-concentration method. The equipment is operated as follows: The incoming cold, raw milk enters a float tank (1), where a constant level is maintained. From this tank, the milk is drawn by suction of a timing pump (2) and is discharged under positive pressure through a plate-type heater (3). The pipe (4) which connects the plate-type heater to the weight-loaded valve (5) has a holding time of 5 sec. The temperature of the milk is controlled by a regulator (6) and a recording controller (7) actuated by a thermal bulb (8) which is located in the outlet of the pipe (4) and ahead of a weight-loaded valve (5). The

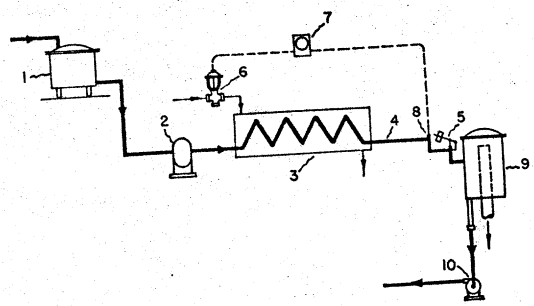

FIG. 2. Diagrammatic drawing of equipment for pasteurization-deodorization-concentration method of processing milk for cheese making.

heat-treated milk under pressure passes through the weight-loaded valve into the vapor-liquid separator (9).

The milk is flash-cooled in the vapor-liquid separator to a definite fixed and controlled temperature corresponding to the vacuum in the separator. At this stage, water is removed (and also volatile flavors) at a rate of 1/10-lb of water per 1 lb of milk per 100 F drop in temperature.

The heat-treated, deodorized, concentrated, and cooled milk is removed from the vapor-liquid separator with a pump (10), which propels the milk to the cheese vats.

PILOT PLANT TESTS

Fourteen lots of high-grade raw milk were processed with the steam-injection method at four different combinations of preheating and deodorizing temperatures, along with conventionally pasteurized controls. Samples were evaluated for flavors by the laboratory's experienced ten-man taste panel. The temperature, holding times, and scores are summarized in Table 1.

The data show no significant effect of processing on the flavor of high-grade milk. Most of the experimental samples were stored at 34 F for from seven to ten days and regraded. No change in flavor was detected.

Results of later experiments again showed that the flavor score of high-grade milk proc-

TABLE 1

Initial flavor scores of high-grade milk pasteurized in the steam injection–deodorization equipment

No. of expts.	Preheat	Steam injection	Holding time	Deodorization	Average score
	(F)	*(F)*	*(sec)*	*(approx F)*	*(one day old)*
14	120	163	15	118	38.3
14	130	163	15	128	38.5
14	140	163	15	137	38.2
14	150	163	15	147	37.9
14	Control samples—HTST plate pasteurized				38.0

essed with the steam-injection method was initially about the same as that of the conventionally pasteurized controls. However, and of great importance, after storage at 34 F for 3 wk the steam-injected vacuum-treated milk usually was scored about seven points higher than the corresponding controls, chiefly because it did not develop an oxidized flavor as did the controls. The failure to develop an oxidized flavor was not due to the removal of oxygen, because when air was bubbled through the steam-injected vacuum-treated milk for an hour it did not develop an oxidized flavor during storage at 34 F for 21 days. Also, tests for homogenization indicated no change in fat dispersion as determined by Ashworth's (1) turbidimetric procedure for homogenization efficiency. Representative data are shown in Table 2. Failure of the steam-injected vacuum-treated milk to develop an oxidized flavor during storage is in harmony with the findings of Shipe (3).

Eleven lots of low-grade raw milk were processed at varied temperature and vacuum levels with the concentration-deodorization method, along with conventionally pasteurized controls. Samples were evaluated by the laboratory's taste panel. Initially, the pasteurized, concentrated, and deodorized milks were scored 1.8 points higher than the controls (37.4 versus 35.6) and six points higher (36.8 versus 30.8) after storage at 34 F for 1 wk. Five of the 11 experimental samples were stored 2 wk, and no significant change in score was detected. Results are summarized in Table 3.

In many other experiments good-grade milk was heated to 173 F (± 2 degrees) in the plate-type heater and held for 5 sec, then flash-cooled to 95 F under vacuum in the vapor-liquid separator. Approximately 0.075 lb of water (and also volatile flavors) was removed per pound of milk. The processed milk always gave a negative phosphatase test and bacteria counts showed extremely effective pasteurization. A temperature of 173 F and a holding time of 5 sec was selected because such a treatment yields a negative phosphatase test (2) and because higher temperatures and longer holding times tested in this study resulted in adverse effects on the moisture content, body, and texture of Cheddar cheese made from milk so treated.

Cheddar cheese was made from many lots of milk pasteurized at 173 F for 5 sec and vacuum-cooled to 95 F as described above, and from corresponding lots of milk pasteurized conventionally at 163 F for 15 sec. Measurements of total solids by the Mojonnier method showed that the vacuum-treated milk had been concentrated about 8%. The cheese were ripened in a conventional manner and graded at three and six months. Those made from deodorized and slightly concentrated milk were scored the same or slightly better than the controls. The body, texture, and flavor characteristics of the cheeses made from slightly concentrated milk were not adversely affected.

The above results indicate that through the use of slightly concentrated milk, the capacity

TABLE 2

Stability of flavor scores of high-grade milk pasteurized in the steam injection–deodorization equipment

Preheat	Steam injection	Holding time	Deodorization	Flavor score Days stored at 34 F			
				1	7	14	21
(F)	*(F)*	*(sec)*	*(approx F)*				
120	163	15	115	37.3	37.3	37.6	37.4
130	163	15	125	37.7	37.8	37.1	37.1
140	163	15	135	37.0	37.7	37.6	37.4
150	163	15	145	37.7	37.3	37.2	37.4
Control samples, HTST plate pasteurized				37.0	30.0	30.5	30.6

TABLE 3

Flavor scores of low-grade milk pasteurized and concentrated in the concentration-deodorization equipment

No. of expts.	Treatment	Average score
11	Pasteurized, deodorized, and condensed, one day old [a]	37.4
11	Pasteurized, deodorized, and condensed, 1 wk old	36.8
5	Pasteurized, deodorized, and condensed, 2 wk old	37.1
11	HTST (163 degrees—15 sec) control, one day old	35.6
11	HTST (163 degrees—15 sec) control, 1 wk old	30.8

[a] Storage temperature was 34 F.

of a cheese plant could be increased about 8% without additional cheese vats, and that the volume of resulting whey could be reduced about 9%, thus increasing its value for concentration or drying.

The operational design and procedure of the modified steam-injection equipment described above differ significantly from those of commercial pasteurizing and deodorizing equipment. The heat from the injected steam is utilized directly in pasteurizing preheated milk instead of being used to further raise the temperature of hot pasteurized milk prior to its deodorization. Thus, less heat is required for the pasteurization-deodorization procedure. Furthermore, it permits operation of the deodorization procedure at a considerably lower temperature than with present equipment. Thus, it requires less refrigeration for cooling the milk after it has been pasteurized and deodorized.

With most commercial equipment, the milk is steam-injected to a higher temperature after pasteurization in order to deodorize it. However, some workers believe that heating to high temperature fixes certain objectionable flavors and often causes them to become toasted or cereal-like. With equipment designed by the Dairy Products Laboratory, the milk need not be heated above the legal requirements for pasteurization and, at the same time, it provides deodorization conditions similar to those of commercial equipment.

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